

ON THE
FRONTAL SINUS*.

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IN this memoir I propose communicating to the Society the general results of my observations concerning the mode of formation, average extent, and peculiarities, which characterize the frontal sinuses in the human cranium; and when we consider the influence which their development has over the configuration, not only of the cranial, but also of the facial bones, we shall attach due interest to every investigation into their history. With the existence of these sinuses the older anatomists, at least those who immediately succeeded Galen, were not unacquainted, for they were described by Columbus, and Laurentius points them out as demanding especially the consideration of the operating surgeon. It need scarcely be observed, that Vesalius, Albinus, Paaw, Winslow, Cheselden, Monro, and other distinguished anatomists, have likewise described them: but with reference to their origin, they state only, in general terms, that they arise from the diplœ having, where they exist, become ex-

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hausted between the cranial tables; which, after all, amounts to no more than a bare acknowledgment that such cavities do exist. Sœmmering, in speculating on their origin, hazards the supposition, that bony substance, or diplöe, is first deposited, and then absorbed for the purpose of leaving these spaces; an explanation which appears somewhat clumsy, and which, at any rate, he did not support by any corroborative testimony. Ackermann has had recourse to a theory which appears to me still more fanciful and untenable: he states, that air being drawn up, in the act of inspiration, through the nasal passages, insinuates itself between the tables of the frontal bone, and, by striking against them, mechanically separates them from each other; which hypothetical explanation is refuted at considerable length, under the article *Crâne*, in the *Dictionnaire des Sciences Médicales*. It is remarkable that even Sabatier attaches some importance to this vague surmise;—but, without proceeding to adduce other theories which have been proposed to explain their origin, and which appear alike unsatisfactory, I may briefly premise, that the one which has been recently propounded by the learned and ingenious Dr Milligan, appears to me sufficiently satisfactory; yet, before explaining how his views are coincident with my observations, I must state, which I shall do briefly, the general results of my inquiries concerning the growth of the head at different periods of life.

It is evident that the most conclusive method of obtaining information on this subject, would be to measure the same head at different successive ages; but this, for obvious reasons, has not been hitherto in my power. To supply this desideratum, therefore, I ascertained the extent of the required dimensions of the head in a great number of subjects of the same age, and then found the average extent of each dimension at that period of life. I then arranged in another class the heads of persons of the same, but of a more advanced age; and, after obtaining the individual, found the average dimensions of these; then, by comparing these averages together, deduced the general amount of these dimensions at the ages chosen, and their average increment between the periods allotted to each class. It appears by this investigation, that, during the first four years of life, the head increases equally in all its directions, *i. e.* in its longitudinal, trans-

verse, and vertical dimensions, and, at the same time, the face increases nearly an inch in length, and a full inch in breadth. The growth of the head is more rapid during this than during any subsequent period of life. Immediately after this, between four and seven years of age, a remarkable difference in the mode of development is observed, for the head does not continue to maintain a similar ratio of growth in all its different directions; but, instead of this, the transverse gains on the longitudinal dimension, and there is scarcely any increase in its growth behind the meatus *externus*.

This accords well with the observations of Sir William Hamilton, who, by weighing the cerebellum and measuring the size of the cerebellar cavities, ascertained that the cerebellum attains its maximum relative size at three years of age. By taking a profile view of the posterior region of the head of a child, and comparing it with a profile view of the head of an adult, the eye will soon familiarise itself with this fact.

From the age of four to that of seven years, it has just been said that the transverse gains on the longitudinal dimension; and it is worthy of remark, that immediately after this period, *i. e.* from seven to fourteen, the head increases so much in length, that the longitudinal now gains sensibly on the transverse dimension. This increase of development takes place, it is to be remembered, anterior to the external meatus, and is nothing more than the progress which the external table of the frontal bone makes in accompanying the growth of the facial bones to which it is attached, and which, at the same time, extend their distance considerably from the meatus. The frontal bone, however, during this period, increases little or nothing in breadth, the growth being principally from the meatus forwards; hence it becomes obvious, that, instead of maintaining a similar ratio of growth in all its directions, one dimension of the head exceeds in the rapidity of its growth another dimension, and one region of the head increases in size, while another remains stationary.

Having thus stated the general results of these investigations concerning the growth of the head, let us consider the application of these facts, and the mode in which, consistently with them, the frontal sinuses become developed. Before the head increases so much in its longitudinal dimension, that is, before

seven years of age, the cranial tables are closely approximated, but about that age (*i. e.* seven), the brain having attained its full complement in size, the internal table is fixed in its position. It is now the true osseous case of the full sized brain, and every farther bony deposition takes place interstitially, which accounts for the superior hardness of this, which has been, consequently, called the “vitreous” table of the skull. That the brain does attain its full size at this early period of life, as was suspected by the Wenzels, whose induction resting only on *two* cases, proved nothing, was shewn by Sir William Hamilton, who not only confirmed their opinion, by weighing the encephalon at every age, but also shewed that the skull of a child does not contain more sand than that of an adult, although the dimensions viewed externally differed extremely. Now, at this period, the brain requiring no further deposition of cerebral substance, the branches of the external carotid arteries will assume a greater activity of function *, and deposit that osseous matter which visibly increases the size of the facial and frontal bones. Connected as the external table of the frontal bone is to the facial bones, it is evident that when these facial bones start forward, the frontal bone must accompany their development, which it does without sympathizing with, or carrying along with it, the internal cranial table. What then happens? It is clear that, when the external table is gradually, in its advancement forwards, separating from the internal table, an opening must be thereby made, which would be filled with diplöe; but that the vessels of the Schneiderian membrane in contact at this point, irritated by the change of position, and forming the membrane with much greater vigour and rapidity than the bony diplöe, extend into this nasal cavity. Hence, as stated by Dr Milligan, a membrane is speedily shot into the nascent hollow or sinus, which attaching itself to the outer aspect of the vitreous table and the inner aspect of the osseous table, forms an insurmountable obstacle to the rudest diplöe that might join these two layers, for it is a mucous membrane, a class of tissues which scarcely ever forms adhesions, and is here almost a shut sac, whose sides are every day brought farther and farther asunder†.”

* This law of “*re-stagnation*” is explained at length, and applied to other phenomena of evolution, by Dr Milligan, in his valuable Appendix to his Translation of Majendie.

† Ibid. p. 604.

In confirmation of this view, numerous facts present themselves, which are of a positive, not of a negative character :—

I. I may refer to the period of life when these sinuses become developed, for although it has been asserted by a celebrated cranial theorist, that the sinuses do not exist in young persons, but only in old persons, or after chronic insanity, yet this assertion is contrary to all previous authority, and opposed to the most direct evidence of Nature. Eyssoniuss, Coiterus, Fallopius, Riolan, Vidus Vidian, Bartholin, Ruysch, Duverney, Portal, Bertin, Sabatier, Bichat, and others, state the non-existence of these sinuses in infants, but describe them as occurring about puberty ; and the latter, especially, attributing their expansion to its proper cause, viz. the development of the external table of the skull, states that they can only be formed at that period when this development takes place, which, as we have seen, commences after seven years of age. The anatomy, too, of the inferior animals refutes, it would appear, the asseveration, for Cuvier remarks, “ *C'est une règle générale pour tous les carnassiers, ils (les sinus frontaux) ne prennent leur développement qu'avec age **.”

II. Every sinus is lined with a mucous membrane, a fact known to the earliest anatomists who paid attention to this subject ; and here it may be remarked, that when, owing to any impediment, such as the narrowness of the nasal passage, this mucous membrane has not been able to extend between the cranial tables, then the sinus does not exist, and its place is supplied by a deposition of bony diplöe, which now meeting with no obstacle, is freely deposited, and occupies what would otherwise have been the space of the frontal sinus. This view satisfactorily explains the observation of the present Dr Monro, who, alluding to crania without these frontal sinuses, remarks, that “ in such cases the tables are as far separated as if the sinuses existed, for their place in this case is filled up with diplöe †.”

III. It has been shewn that the average increase in the growth of the head, when its longitudinal gains on its transverse dimension, which is entirely owing to the development before the meatus, is $\frac{4}{5}$ ths of an inch, which I found, subsequent-

* Cuvier, *Recherches sur les Ossemens Fossils*, tom. iv. p. 358.

† Monro, *Elements of Anatomy*, vol. i. p. 134.

ly, to be the average depth of the frontal sinuses. Such, then, is the connection which evidently exists between the general growth of the head and the formation of these sinuses.

The average extent of these sinuses next claims consideration, on which subject anatomists have not recorded hitherto any definite observations. Albinus describes them as "cavernas magnas amplissimas prope nasum;" and extending upwards and laterally over the orbits, as far as the middle of the superciliary ridge. Ruysch states that they are often very large, and cites the case of a *puella gigantea*, in whom they extended above the coronal suture, and some way between the tables of the parietal bones. Winslow, Lieutaud, and Palfin, state they vary much in different individuals; but it does not appear that they paid any attention to their average extent. Dr Monro (the present Professor) gives, in his *Elements of Anatomy*, some measurements of the frontal sinuses; but the sinuses to which he refers, are stated to have been unusually large, consequently they do not represent the universality of Nature. I have measured these sinuses in upwards of a hundred crania, and consider that the following may be regarded as their average extent. 1st, Their extent in height is 1 inch $\frac{7}{20}$ ths;—2d, their extent in breadth is 2 inches $\frac{4}{10}$ ths, this is, for each sinus;—and their extent in depth $\frac{4}{10}$ ths of an inch.

Such was their *average* size in the crania examined by me; but, of course, in some individual cases they may be much smaller, or much larger. I shall conclude this memoir by stating the peculiarities by which these frontal sinuses are characterised.

1. The frontal sinuses originate under each os unguis, and thence extend, in the manner described by Albinus, laterally and vertically, over the orbits. Their origin at this point is evidently owing to the extension of the mucous membrane lining the nasal cavities, which creeps from under this bone, to extend between the cranial tables.

It is remarkable that Gagliardi has not only erroneously described, but has given a plate to his work, in which these sinuses are represented in an erroneous position *.

2. The sinus is most commonly divided by a septum, which generally runs down the mesial line; but often inclines much to the right, or much to the left side. In illustration of this, I may refer to the Anatomical Museum of the University (Dr Monro's), wherein will be found five skulls sawn open, to show these sinuses, rather large. In No. 104,

* *Gagliardi Anat. Ossium, 1723.*

specimen B, the septum inclines to the left. In specimen D (same case) it inclines to the right.

In the collection of crania labelled by Dr Spurzheim, now in the Edinburgh College Museum, and which Professor Jameson permitted Sir William Hamilton to open, the septum appears in a great many to have been incomplete; that is, not extending from the posterior to the anterior wall of the sinus. As Bertin and other anatomists have observed, in such crania, the sinus of the right communicates with the sinus of the left side.

3. Palfin, Sabatier, Monro secundus, and other anatomists, have stated that the frontal sinus is often divided by many *complete* septa; but in upwards of one hundred crania, not one appeared corresponding to this description.
4. The frontal sinuses are on each side generally unequal in size; but the remark of Vieussens is not correct, that the right cavity is always larger than the left, (*quorum dexter sinistro semper amplior est* *). In the collection preserved in the Natural History Museum, specimens 42 and 47 will be found to have the left larger than the right sinus; but in the specimens 9, 5, 4, 26, the right sinus is larger than the left. Many anatomists have remarked, that the sinuses are on each side generally equal; but this is evidently incorrect. It may, however, be stated, that the right sinus is more frequently larger than the left, than the left is larger than the right sinus.

In some instances the sinus is found of its usual size on the *right* side, and only a mere vestige of its existence on the *left*, as may be seen in specimens 17, 36, 45, of the same collection; and, in some instances, the sinus appears of its ordinary dimensions on the left side, with only its rudimentary cell discernible on the right; which may be observed in specimens 28, 33, 50, of the same collection.

5. The non-existence of the frontal sinus is very rare; and many anatomists, who have affirmed the contrary, have misguided themselves, by not looking for it in the proper place,—a fact which did not escape the observation of Sabatier, who, contradicting the authority of Fallopian on this point, remarks, “ C'est sans doute une inadvertance de sa part, car on les rencontrent aisément quand on a la precaution de scier la crâne plus bas qu'à l'ordinaire †.”

It is worthy of observation, that Winslow remarks, “ the frontal sinuses are sometimes completely wanting, and in such subjects the internal cavity of the nose is larger than ordinary ‡.”—I may add, that, in the collection of crania in the Edinburgh University, there are only three specimens in which the frontal sinuses appear to be wanting; but in each of these, its elementary cell is visible under each os unguis;—so that not one specimen in this collection completely wants the frontal sinus.

* Vieussens Neurograph. Univers. lib. i. c. cxvi, p. 103.

† Sabatier, Traité d'Anat. tom. i, p. 32.

‡ Winslow, Anatomy of the Human Body, p. 23.

6. It is impossible by *any* external examination of the cranium to predicate whether it possesses a large or a small frontal sinus; an idea entertained by many, who imagine that the size of the sinus is indicated by the greater or lesser prominence of the superciliary ridge. This is an error. A large superciliary ridge often exists over a very small sinus; and scarcely any superciliary ridge at all is sometimes discernible, when a very large sinus exists underneath. In specimen 28 (in the collection of crania already referred to) scarcely any sinus is visible on the right side, yet the superciliary ridge above it is strongly marked. In specimen 49 only a vestige of the sinus exists, yet the superciliary ridge is large. In specimens 2 and 29 the sinuses are small, yet the superciliary ridges strongly marked. Whereas, on the other hand, in specimens 8, 23, 34, the superciliary ridges are nearly wanting, yet the sinuses beneath are large. No correlation whatever, therefore, exists between the size of the superciliary ridges and the extent of the frontal sinus.

It may be added, that the greater or lesser fulness of the frontal bone in this region does not in the slightest degree assist our predictions; for the size of the sinus, depending entirely on the extent to which the mucous membrane has risen between the cranial tables, preventing there the deposition of diplöe, admits of no external sign.

7. The depth of the sinus bears no proportion whatever to its extent in breadth or height. The sinus (as in specimen 16) is sometimes nearly two inches in height, and three in breadth, yet the depth the same as in crania which have the sinuses very small, as in specimen 33, where the sinus does not extend either an inch in height or an inch in breadth.
8. *Vidus Vidian, Duverney, Dupuytren, and many anatomists, agree in stating, that the frontal sinuses attain their greatest extent in old age; but neither my observations, nor those of Sir William Hamilton ** corroborate this statement. On the contrary, it appears that the sinuses are generally very small in old age, as may be seen by the specimens 13, 21, 22, 50,—crania which bear all the indications of old age.
9. The frontal sinuses appear to possess some national peculiarities. They appear to be generally small in the crania of the Irish—but very large in the crania of the French, Swiss, and Germans. They are small in Negro and Carib crania; and in the crania of the Hindoos they extend high, but are not deep. In the cranium of the Red Indian, which is preserved in the Edinburgh Museum, they are very small †.

* Sir William Hamilton, whose critical acumen is well known, pointed out to me this, and many other curious facts connected with cranial anatomy. To his investigations, both on this subject and on the cerebellum, anatomists and physiologists are much indebted.

† The cranium of the Red Indian was brought from Newfoundland by one of Professor Jameson's pupils, William Cormack, Esq. and is the only specimen in Europe. It is very valuable, as the Red Indian tribe is now extinct.

